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XVII.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE, UNDER THE DIRECTION OF E. L. MARK, LXIV.

PRELIMINARY NOTES ON THE EMBRYOLOGY OF THE STARFISH (ASTERIAS PALLIDA).

By Seitaro Goto.

Presented by E. L. Mark, April 8, 1896.

In this preliminary notice I propose to give a brief account of the principal results of the study which I have been carrying on during the past winter. Since I began my study, two papers in the "Quarterly Journal of Microscopical Science," covering the same ground in other species, have come to my notice, one by Bury, and the other by MacBride. But as the results of these observers are at variance on some important points, it will, I believe, not be without interest to publish my own, which, it will be seen, are mostly, but not altogether, confirmations of those of MacBride.

The material was collected last summer in Mr. Agassiz's Laboratory at Newport, R. I., where I was enabled to work for several weeks through the courtesy of the owner, to whom my best thanks are due. It will be observed that I have studied the same species as that on which Mr. Agassiz himself worked about thirty years ago, — a species which in the course of its development passes through typical Bipinnaria and Brachiolaria stages.

(1) A few words as to the orientation of the body. In the Brachiolaria stage the sagittal plane of the body passes through the dorsal Brachiolaria arm, and is at right angles to the line joining the tips of the other two arms. It also passes through the anus and the middle of the mouth. In later stages, as metamorphosis approaches more and more its end, the anus shifts its position considerably, and the sagittal plane can be determined externally only by means of the Brachiolaria arms. I find the plane determined by this means constant for all practical purposes; that is to say, it bisects the stomach as well as the body as a whole, and passes through both the dorsal pore and the point where

the definitive mouth is formed. As the Brachiolaria arms are visible until a very late stage of metamorphosis, this method of determining the principal plane of the body is very convenient, and at the same time tolerably accurate.

The aboral disk arises, as already known, as a thickened patch of the ectoderm on the right side of the body, and extends also some distance on to the dorsal side; but as metamorphosis progresses, it shifts its position, so that it becomes more and more inclined to the sagittal plane, and at the same time more nearly parallel to the crossplane, i. e. a plane perpendicular to the chief axis of the body. The position of the dorsal pore remains nearly, although not quite, constant.

From the above it follows that the oral side of the adult is the anterior, the aboral the posterior, the madreporic (interradius) the dorsal, and the side opposite this the ventral, side of the larva. Right and left sides are evident from what precedes.

(2) As has been partly suggested in the foregoing lines, both the definitive mouth and anus are new formations.

(3) Of the body cavity in the larva I distinguish, with Bury, four portions, an anterior and a posterior on either side of the body. In the fully developed Bipinnaria, these portions are all directly or indirectly continuous with one another; but in the course of the Brachiolaria stage the right posterior portion is entirely cut off from the remaining parts, and later, when the tentacles of the Bipinnaria have been largely drawn in, another septum is formed anterior to the first, while the left posterior portion also becomes constricted off from the rest; so that at this stage there are three separate cavities, viz. (1) the right posterior, (2) the left posterior and the right middle portions, which still form but one cavity, and (3) the right and left anterior portions, which freely communicate with each other in the Brachiolaria arms. The anterior cavity (3) persists in the adult as the axial sinus and the water-vascular system.

The right posterior cavity shifts its position hand in hand with the aboral disk, and finally occupies the posterior end of the larva just beneath the disk. With the development of the arms of the star, it sends out diverticula into them, and thus assumes the bibrachiate, 5-radiate star-shape which it has in the adult.

(4) The formation of the water-vascular ring is not a mechanical result of the breaking through of the adult mouth, for the ring exists as such some time before the mouth is formed.

(5) With Bury and MacBride I distinguish sharply two structures, the pore-canal and the stone-canal. There is a stage when the pore-

canal alone is present. I believe that they are also phylogenetically distinct, the stone-canal being a later formation. In comparing the Echinoderms with such a group as the Enteropneusta it is, as it seems to me, the pore-canal alone that is primarily to be taken into consideration.

(6) The opening of the pore-canal and the stone-canal into the body cavity persists throughout life. This is true not only of *Asterina gibbosa* and *Asterias pallida*, but also of *Asterias tenera*, *Solaster endeca*, and *Cribrella sanguinolenta*, and inferentially of all starfishes. The opening of the stone-canal is always on the right side of the sagittal plane.

(7) In agreement with MacBride, I find that the "dorsal organ" of Bury, the "Centralblutgeflecht" of Ludwig, forms the periœsophageal portion of the body cavity of the adult. It arises in the form of a tube from the left posterior enterocœl just behind the pore-canal. In a young Brachiolaria it encircles about one fourth of the whole circumference of the cardiac portion of the stomach, and it forms a complete ring in a young star that has just finished its metamorphosis. The septum that divides it from the left posterior enterocœl is subsequently completely absorbed except in one place, viz. the madreporic interradius, where it appears to persist throughout the life of the animal. The term "oral cœlom," used by MacBride, seems to me unfortunate, as that term has been applied to another and entirely different cavity (left cœlom) in Crinoids. I therefore prefer to call the structure in question "periœsophageal enterocœl."

(8) The perihæmal spaces (the inner ring excepted) as well as the peribranchial spaces are, according to my observation, of true schizocœl origin.

CAMBRIDGE, April 8, 1896.